Hydrochar for metal removal from acid mine drainage

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Extended Abstract

In an attempt to divert organic waste, including food waste, this study seeks to find uses of hydrochar created from anaerobic digestate from food waste. This is a part of a larger project that seeks uses for food waste including energy production, material production, and water treatment. Hydrochar, shown in Fig. 1, is similar to biochar, but produced through hydrothermal carbonization (HTC) at lower temperatures (180–260 °C) in wet conditions rather than high temperature dry conditions. Hydrochar can be used as a land amendment, sorbent, or ingredient in a bioreactor, akin to biochar, but has little previous work to support its use (e.g. Sharma et al. 2020). In this project, hydrochar is produced from anaerobic digestate from a commercial anerobic digester that processes food waste alongside septage (i.e. sewage from a septic tank). Other work has been conducted in small scale to test the variation in anaerobic digestate properties depending upon the inputs, however, the digestate used in this project was not sourced from those experiments due to the quantities needed, however their source and processing was equivalent.

In this work, we test hydrochar created at different temperatures for direct sorption of Cu, Cd, and Zn at pH 4 and pH 7 (Quardey 2022) and, in ongoing work, regeneration of the sorbent. Understanding that speciation and solubility of metals will vary by pH, PHREEQC and Geochemists Workbench have been employed in analysis of the data. Synthetic mine water was mixed with different masses of hydrochar to determine equilibrium removal of metals. Regeneration of used hydrochar is being tested with HCl, EDTA, and KCl, alongside deionized water.

In parallel experiments, we compare use of hydrochar in a sulfate reducing bioreactor; these trials are ongoing and will be reported in oral presentation. Compost, woodchip, and corn flour bioreactors are being tested with and without hydrochar used akin to biochar in other work. The bioreactor substrates were chosen to divert organic waste streams from the local system. Since hydrochar, like biochar, is an energy intensive product to create, the smaller masses needed for a 5% addition to a bioreactor may be a more practical application than direct sorption.

Hydrochar produced at 260 °C achieved greater than 90% removal of Cu, Cd, and Zn at pH 4, shown in Fig. 2, while at pH 7 precipitation drove metal removal, while hydrochar produced at 180 or 220 °C had lower metal sorption, decreasing with decreasing HTC temperature (Quardey 2022). Cu was removed at a lower percentage than the other metals. When rinsed with deionized water and dilute nitric acid, nearly 100% of the sorbed metals were re-dissolved into solution (Quardey 2022), informing further tests of sorbent regeneration.

The goal of regeneration is both re-use of hydrochar for multiple rounds of sorption and the potential for use as a land amendment after sorption capacity is reduced. Initial results of regeneration experiments suggest that different solvents will be more effective for different metals, requiring optimization. For example, during the first round of desorption, EDTA was the most effective for Cu, while nitric acid was the most effective for Cd and Zn. After two rounds of desorption, the sorption capacity of the hydrochar reduced dramatically. SEM imagery of the hydrochar before and after sorption and after the first round of desorption show a notable change in material

morphology including an increase in surface smoothness and observed surface cracks after desorption with EDTA.

Hydrochar shows initial promise as a sorbent for metal removal from AMD, while the sorbed metals appear to desorb readily. The processing temperature does appear to affect metal sorption using hydrochar and should be balanced with the energy consumption of material production. Remaining questions that are being investigated include how many rounds of sorption will the hydrochar sustain and whether bioreactors containing hydrochar will achieve similar or better results, allowing for conceptual designs of use of hydrochar for metal removal from mine water.

Keywords: Cu, Cd, Zn, organic waste

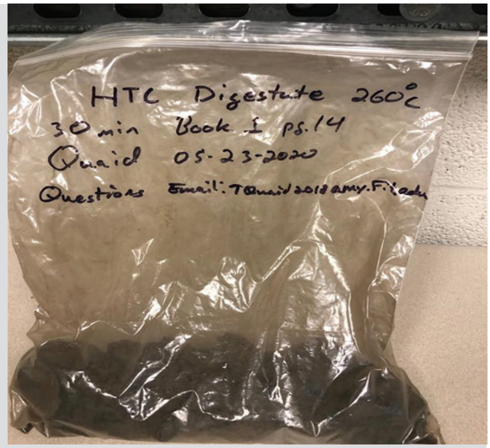

Figure 1 *Hydrochar is produced using hydrothermal carbonization of organic materials, in this case anaerobic digestate. Hydrochar samples tested in this project were produced at different temperatures between 180 °C and 260 °C*

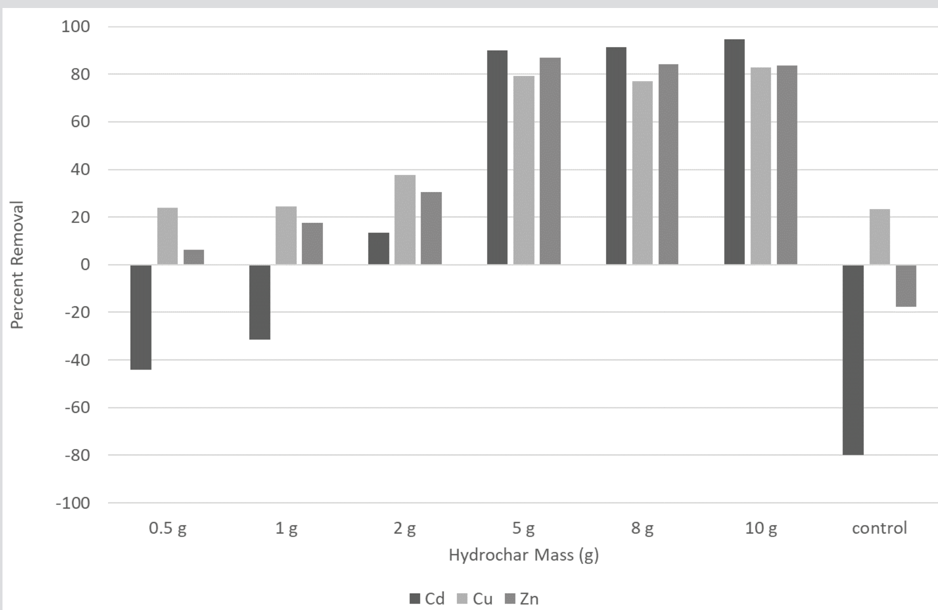

Figure 2 *Percent removal of Cd, Cu, and Zn using hydrochar produced at 260 °C for 30 min from anaerobic digestate in equilibrium, batch scale conditions at pH 4 compared to a control of synthetic mine water only without hydrochar*

Acknowledgements

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References

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